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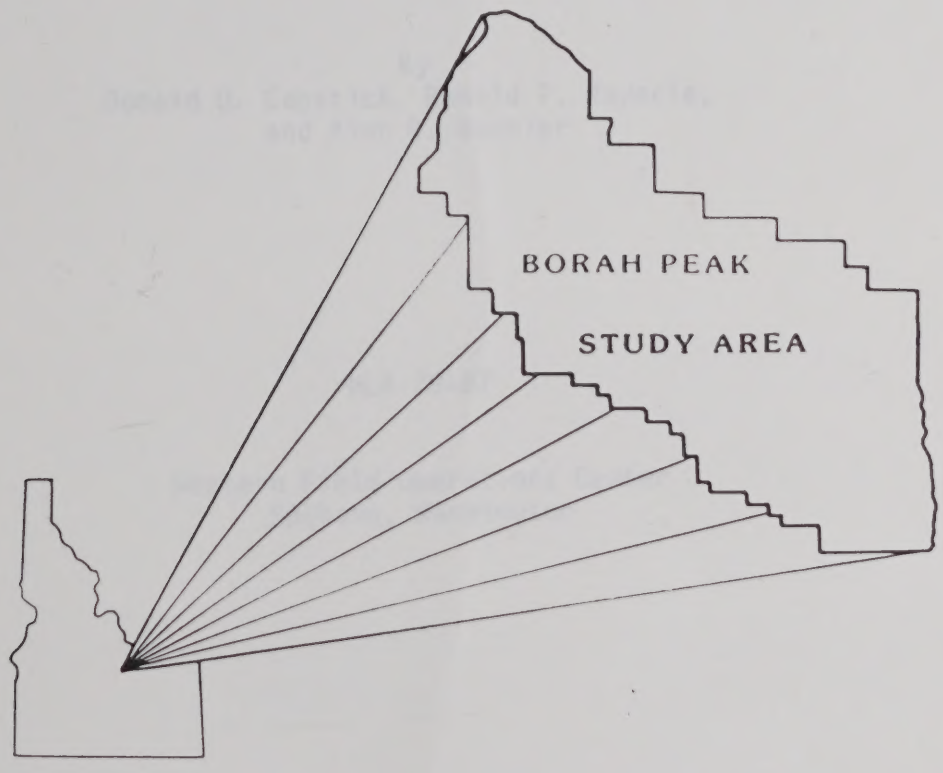
Mineral Resources of the Borah Peak Study Area, Custer County, Idaho



BUREAU OF MINES

UNITED STATES DEPARTMENT OF THE INTERIOR

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MINERAL RESOURCES OF THE BORAH PEAK STUDY AREA, CUSTER COUNTY, IDAHO

By
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and Alan R. Buehler

MLA 79-87

Western Field Operations Center
Spokane, Washington

UNITED STATES DEPARTMENT OF THE INTERIOR
Donald P. Hodel, Secretary

BUREAU OF MINES
David S. Brown, Acting Director

PREFACE

The Wilderness Act (Public Law 88-577, September 3, 1964) and related acts require the U.S. Geological Survey and U.S. Bureau of Mines to survey certain areas on Federal lands ". . . to determine the mineral values, if any, that may be present . . . ." Results must be made available to the public and submitted to the President and the Congress. This report presents the results of a Bureau of Mines mineral survey of the Borah Peak study area, which encompasses the Borah Peak roadless areas and other contiguous U.S. Forest Service administered land, Custer County, Idaho. The roadless areas were classified as Wilderness Recommended (I4210) or Non-Wilderness (X4210) during the Second Roadless Area Review and Evaluation (RARE II) by the Forest Service, January, 1979.

The data for this open-file report were gathered and interpreted by Bureau of Mines personnel from Western Field Operations Center, East 360 Third Avenue, Spokane, WA 99202. The report has been edited by members of the Branch of Resource Evaluation at the field center and reviewed at the Division of Mineral Land Assessment, Washington, DC.

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UNIT OF MEASURE ABBREVIATIONS USED IN THIS REPORT

o	degree
ft	foot
gm/cc	grams per cubic centimeter
in.	inch
mi	mile
%	percent
lb	pound
mi^2	square mile
oz/ton	troy ounce per ton

SUMMARY

A mineral survey of the approximately 144,000-acre Borah Peak study area was conducted by the U.S. Bureau of Mines in 1985 at the request of the U.S. Forest Service. The area studied included the Borah Peak RARE II roadless areas (No. I4210, 119,864 acres of land recommended for wilderness designation; and No. X4210, 18,440 acres. of land recommended as non-wilderness) and other contiguous Forest Service administered land. The study area is in Challis National Forest in southeast Idaho about 30 miles south-southeast of Challis, ID. Burnt Creek, a conterminous study area to the northeast, on lands administered by the U.S. Bureau of Land Managment, was examined concurrently.

Dolomite and limestone inferred reserve bases exceed 1 billion tons each within the Borah Peak study area. The material is widespread and of high quality. Extensive sampling and more detailed mapping are required to better define the resources; however, ample dolomite and limestone occur nearby, outside the study area. Dolomite is the main constituent of several geologic formations within the study area. Sample analyses indicate that the more than 1,000-ft-thick Jefferson Formation dolomite is the most pure and is equivalent to material being mined at a dolomite-to-magnesium processing plant near Addy, WA. Analyses from limestone-bearing formations underlying much of the study area indicate that large quantities of the limestone may be suitable for a variety of uses.

Limestone and dolomite have been used for aggregate and rip-rap within the study area in the past, and possibly for the manufacture of portland cement. While the limestone, dolomite, and limited amounts of sand and gravel found within the study area could be used for this purpose in the future, occurrences just outside the study area are numerous and sufficient to supply local demand.

No metallic mineral resources were identified in the study area. About 90 claims have been located or relocated in the area since the late 1880's; U.S. Bureau of Land Management records indicate only one current claim. There are no patented mining claims. Most of the historic claims were located along the Lost River Fault system which trends parallel to the southwest-facing range front.

Prospect workings are clustered mainly in three groups. The workings explore scattered, small veins and pipe-shaped structures containing elevated concentrations of lead, zinc, and barite, with minor silver, gold, and copper. There are also three isolated prospects in the study area; one explored for barite, and the other two were located on iron-stained zones. In the study area, there are 31 adits, 5 vertical and 2 inclined shafts, 1 bulldozer cut, 33 pits, and 3 trenches. Most of the mineral occurrences are in readily alterable and replaceable carbonate rocks. The minerals may have been remobilized to their present locations from material much deeper in the shattered and permeable rocks of the Lost River Fault zone.

INTRODUCTION

This report describes the USBM (U.S. Bureau of Mines) study to evaluate mineral resources of the Borah Peak study area at the request of the U.S. Forest Service. The USBM examined prospects, claims, and mineralized zones, and evaluated identified mineral resources. Results of the investigation will be used to help determine the suitability of the study area for inclusion into the National Wilderness Preservation System. Although the immediate goal of this and other USBM mineral surveys is to provide data for the President, Congress, government agencies, and the public for land-use decisions, the long-term objective is to ensure the Nation has an adequate and dependable supply of minerals at a reasonable cost.

Setting

About 144,000 acres of the 156,220-acre Borah Peak Management Unit No. 16 (exclusive of the 12,000-acre Spring Hill portion north of Forest Road 117) was studied (fig. 1). The area, in southeast Idaho, includes the Borah Peak RARE II Wilderness Recommended unit (I4210) of 119,864 acres, the Non-Wilderness Recommended unit (X4210) of 18,440 acres, and other contiguous Forest Service administered land. The study area's northern boundary is about 30 mi southeast of Challis, ID, and its southern terminus is just east of Mackay, ID (fig. 1). The northeast boundary of the study area adjoins the BLM (U.S. Bureau of Land Management) administered Burnt Creek study area (fig. 2), which was examined concurrently (Gabby, 1986).

The 25-mi-long by 10-mi-wide study area trends north-northwest along the Lost River Range. Access into the foothills and canyons of the steep southwest-facing range front is by dirt roads from U.S. Highway 93. The northwest and southeast portions of the study area are bounded by well-maintained Forest Service dirt roads. Other Forest Service and BLM dirt roads access the foothills and canyons along the northeast boundary.

The study area contains both high-desert and mountainous environments and is extremely rugged. High cliffs are numerous, and drainages are narrow and steep. Relief from the foothills, along the western range front, to the summit of Borah Peak is over 5,600 ft and occurs within about 3 mi. At 12,662 ft, Borah Peak is the highest point in Idaho. The lowest point in the study area is 6,150 ft at the southeast corner along Pass Creek. Annual precipitation ranges from 7 to 10 in. in the lower foothills to 35 to 40 in. at higher elevations, most of which falls in the autumn and winter months as snow. Sagebrush, desert grasses, and a few scattered juniper trees grow in the lower areas, particularly along the southwest boundary. Where favored with sufficient ground water, meadow grass and aspen are present, particularly in glaciated valleys and along the northeast side of the study area. As elevations increase, scattered pine thickens to stands which dominate the scene to treeline.

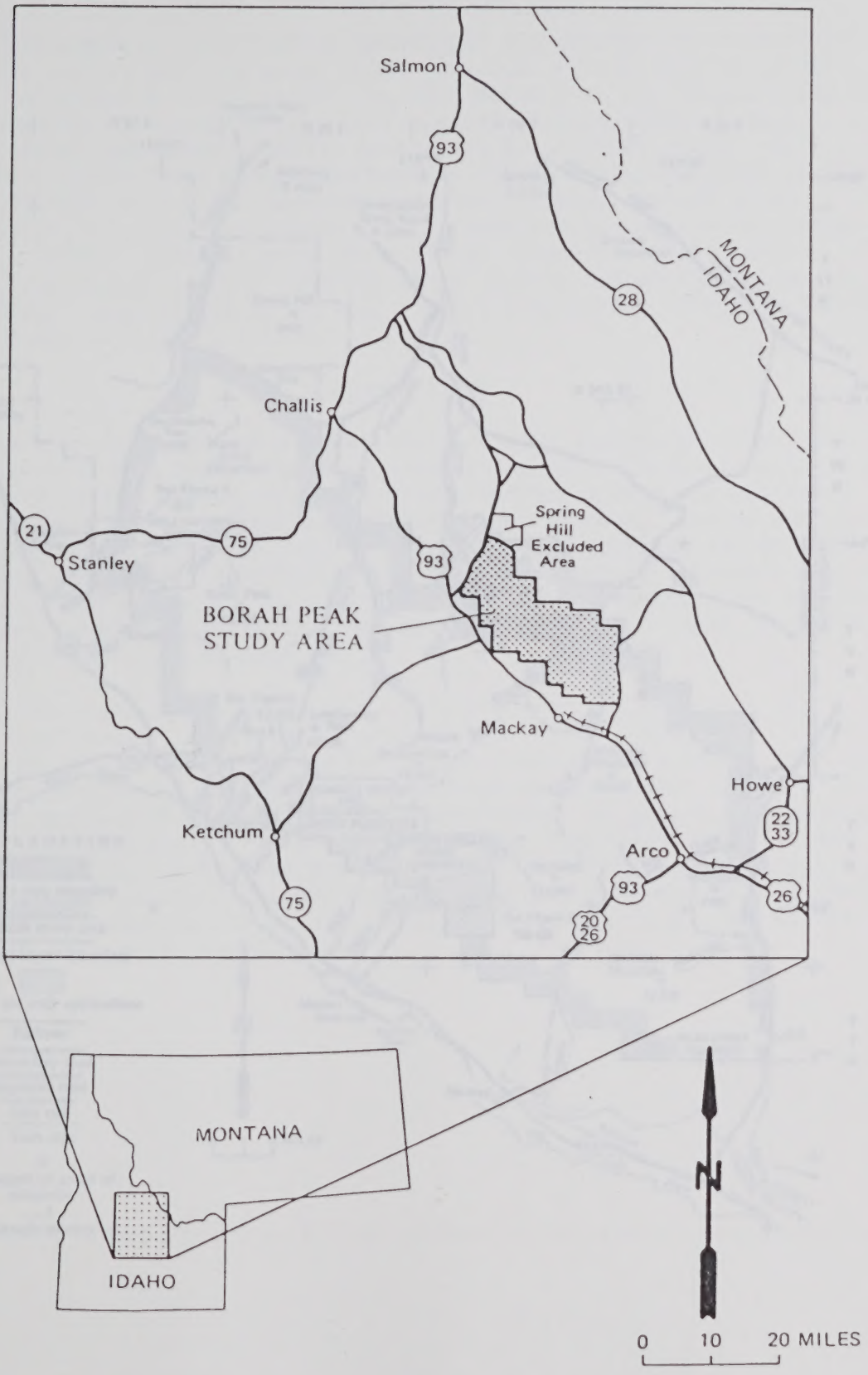


FIGURE 1.— Location of the Borah Peak study area, Custer County, ID

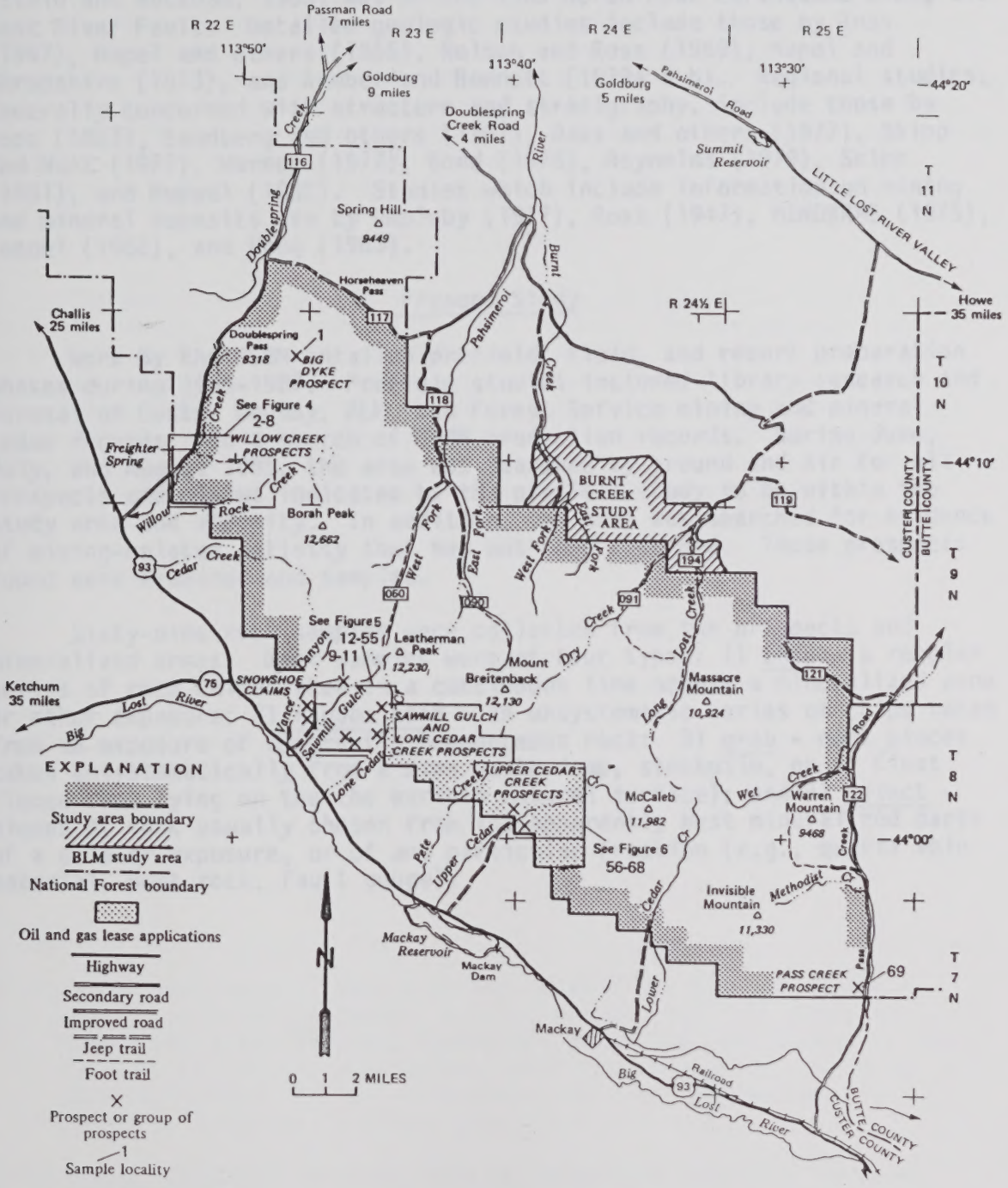


FIGURE 2.– Prospects in the Borah Peak study area, Custer County, ID

Previous Studies

Both regional and detailed geological and geophysical studies have been done in and near the study area. The most recent detailed study (Stein and Bucknam, 1985) was of the 1983 Borah Peak earthquake along the Lost River Fault. Detailed geologic studies include those by Ross (1947), Mapel and others (1965), Nelson and Ross (1969), Mapel and Shropshire (1973), and Rember and Bennett (1979a & b). Regional studies, generally concerned with structure and stratigraphy, include those by Ross (1963), Sandberg and others (1967), Oaks and others (1977), Skipp and Hait (1977), Warner (1977), Bond (1978), Reynolds (1979), Skipp (1981), and Ruppel (1982). Studies which include information on mining and mineral deposits are by Umpleby (1917), Ross (1947), MINOBRAS (1975), Ruppel (1982), and Wong (1983).

Present Study

Work by the USBM entailed prefield, field, and report preparation phases during 1985-1987. Prefield studies included library research and perusal of Custer County, BLM, and Forest Service mining and mineral lease records, and a search of USBM production records. During June, July, and August 1985, the area was searched by ground and air for all prospects and claims indicated by the prefield study to be within the study area and vicinity. In addition, the area was searched for evidence of mining-related activity that had not been recorded. Those prospects found were examined and sampled.

Sixty-nine rock samples were collected from the prospects and mineralized areas. Rock samples were of four types: 1) chip - a regular series of rock chips taken in a continuous line across a mineralized zone or other exposure; 2) random chip - an unsystematic series of chips taken from an exposure of apparently homogeneous rock: 3) grab - rock pieces taken unsystematically from a mine waste dump, stockpile, or of float (loose rock lying on the the earth's natural surface); and 4) select - pieces of rock usually chosen from the apparently best mineralized parts of a pile or exposure, or of any particular fraction (e.g., quartz vein material, host rock, fault gouge).

Of the 69 rock samples, 68 were analyzed to determine the concentration of specific elements, one was petrographically examined, and the specific gravity of one sample was determined. Of the 68, 29 were analyzed by semiquantitative emission spectroscopy for 40 elements 1/, and 39 were analyzed by plasma emission spectroscopy (inductively coupled argon-plasma) for 33 elements 2/. All 68 analyzed samples were fire-assayed for gold and silver. X-ray fluorescence was used to determine the concentration of barium in 28 samples and tungsten trioxide in 1 sample. Thirteen were analyzed by atomic absorption (all for lead, nine for zinc, and three for copper). The specific gravity of one barite sample was determined by weight comparison (weight in air to weight immersed in water). Complete analyses are listed in the appendices.

ACKNOWLEDGEMENTS

The authors are grateful to William N. Savage of the Challis National Forest Supervisors Office and to Howard Rosenkrance of the Mackay District Office for providing information from their files and sharing personal knowledge of mining-related activity. We are especially grateful to Wiley and Carolyn Smith for providing historical and access information, and for their many courtesies. Terry J. Close, Andrew M. Leszcykowski, Richard L. Rains, and Richard A. Winters of Western Field Operations Center, USBM, assisted with the field investigation.

1/ Aluminum, antimony, arsenic, barium, beryllium, bismuth, boron, cadmium, calcium, chromium, cobalt, copper, gallium, gold, iron, lanthanum, lead, lithium, magnesium, manganese, molybdenum, nickel, niobium, palladium, phosphorous, platinum, potassium, scandium, silicon, silver, sodium, strontium, tantalum, tellurium, tin, titanium, vanadium, yttrium, zinc, and zirconium.

2/ Aluminum, antimony, arsenic, barium, beryllium, bismuth, cadmium, calcium, chromium, cobalt, copper, iron, lanthanum, lead, lithium, magnesium, manganese, molybdenum, nickel, niobium, phosphorous, potassium, silver, sodium, strontium, tellurium, tin, titanium, tungsten, vanadium, yttrium, zinc, and zirconium.

GEOLOGIC SETTING

Structure

The Precambrian and Paleozoic rocks of the Lost River Range, which underlie the study area, are part of a large Mesozoic-age thrust plate (Skipp and Hait, 1977). The study area is characterized by extensive north-northwest-trending horst (uplifted block) and graben (downdropped block) structures typical of the Basin and Range province (Reynolds, 1979, p. 188) 3/. The horsts are modified by significant north-south block faults. Lesser east-west (and northeast-southwest) block faulting has resulted in secondary horst (and graben) development, of which the Borah Peak horst is one (Ross, 1947, p. 1135-1139; Ruppel, 1982, p. 4, 17). Intensely folded rocks and numerous north-northwest-trending synclines and anticlines are evidence of the structural adjustments affecting the area (Ross, 1947, p. 1088, 1125-1135). Faulting continues today. In 1983, the east side of the Lost River Fault, which extends along the western range-front, made an average relative vertical upward adjustment of 6.5 ft, causing the 7.1 magnitude Challis (Borah Peak) earthquake (Stein and Bucknam, 1985, p. iv and v-viii).

In many cases faulting causes brecciation of country rock along strike, creating a permeable zone where mineral-bearing fluids can move with relative ease. Within the study area, most of the visible alteration, base-metal mineralization, and mining exploration occurred in the intensely fractured zones of the Lost River Fault system, particularly where readily alterable and replaceable carbonate rocks occur. The base-metal mineralization occurs as small, discontinuous scattered veins or pipe-shaped structures of various attitudes. The sought-after minerals in these occurrences are mainly barite, galena (lead), sphalerite (zinc), and silver; minor gold and copper minerals are also present. Gangue and altered wallrock minerals include quartz, calcite, barite, goethite, limonite, and pyrite.

3/ Ruppel (1982, p. 8 and 21), in making a case for a somewhat different structural environment, states that ". . . [the mountain ranges] are better described as flat topped block uplifts flanked by monoclinal folds . . . ."

Ruppel (1985) stated that the abundant mineral deposits in the Lemhi Range to the northeast occur at the base of the Medicine Lodge Thrust (fault) and that similar deposits may occur at the base of that thrust where it is deeply buried beneath the Lost River Range. Hydrothermal fluids ascending from depth may have dissolved minerals from these deposits and transported them up along the high-angle fault systems to an environment favorable for deposition. The mineral occurrences found in the study area, mostly along the western range-front, may be a result of this remobilization and deposition.

Stratigraphy

Paleozoic sedimentary rocks are the most common exposed within the study area (Rember and Bennett, 1979a & b). The oldest rocks are Ordovician or older quartzites exposed on the south flank of Borah Peak. Overlying the quartzites, and cropping out over most of the study area, are Silurian- to Carboniferous-age dolomites and limestones of possible economic significance. On the north and east sides of the study area, latite-andesite and basalt of the Tertiary Challis Volcanics overlie the sedimentary rocks (fig. 3). Quaternary-age glacial deposits are abundant in the study area; particularly in valleys on the north side. Unconsolidated alluvium covers semi-consolidated fanglomerates in the valleys.

Among the several dolomite formations in the study area, the Jefferson dolomite is probably the most economically significant. It crops out extensively in the general vicinity of Borah Peak and also forms a broad band on the lower slopes of the Lost River Range between Upper Cedar and Lone Cedar creeks. The formation is composed mainly of dark bluish-gray dolomite. Analyses by Mapel and others (1965) north of the study area indicate that the Jefferson dolomite is more pure and has fewer interbeds of quartzite that the dolomite in other nearby formations. The thickness of the formation in the study area is thought to be greater than 600 ft, but the beds are intricately deformed, and measurable sections of the entire unit were not found. Studies by Sloss and Laird (1946) lead them to regard the Jefferson dolomite in Montana as Upper Devonian in age.

Three limestone formations, all of possibly economic significance, underlie most of the study area (fig. 3). Differentiation of the formations was not practical at the map scale shown. The formations are, from oldest to youngest, the Three Forks, 30 to 200 ft of argillaceous limestone; the Milligen, 1,000 ft of carbonaceous shale; and the Brazer, 4,000 ft of relatively pure limestone but locally being siliceous or magnesian.

A more detailed discription of the stratigraphy is available in Ross (1947, p. 1099-1125).

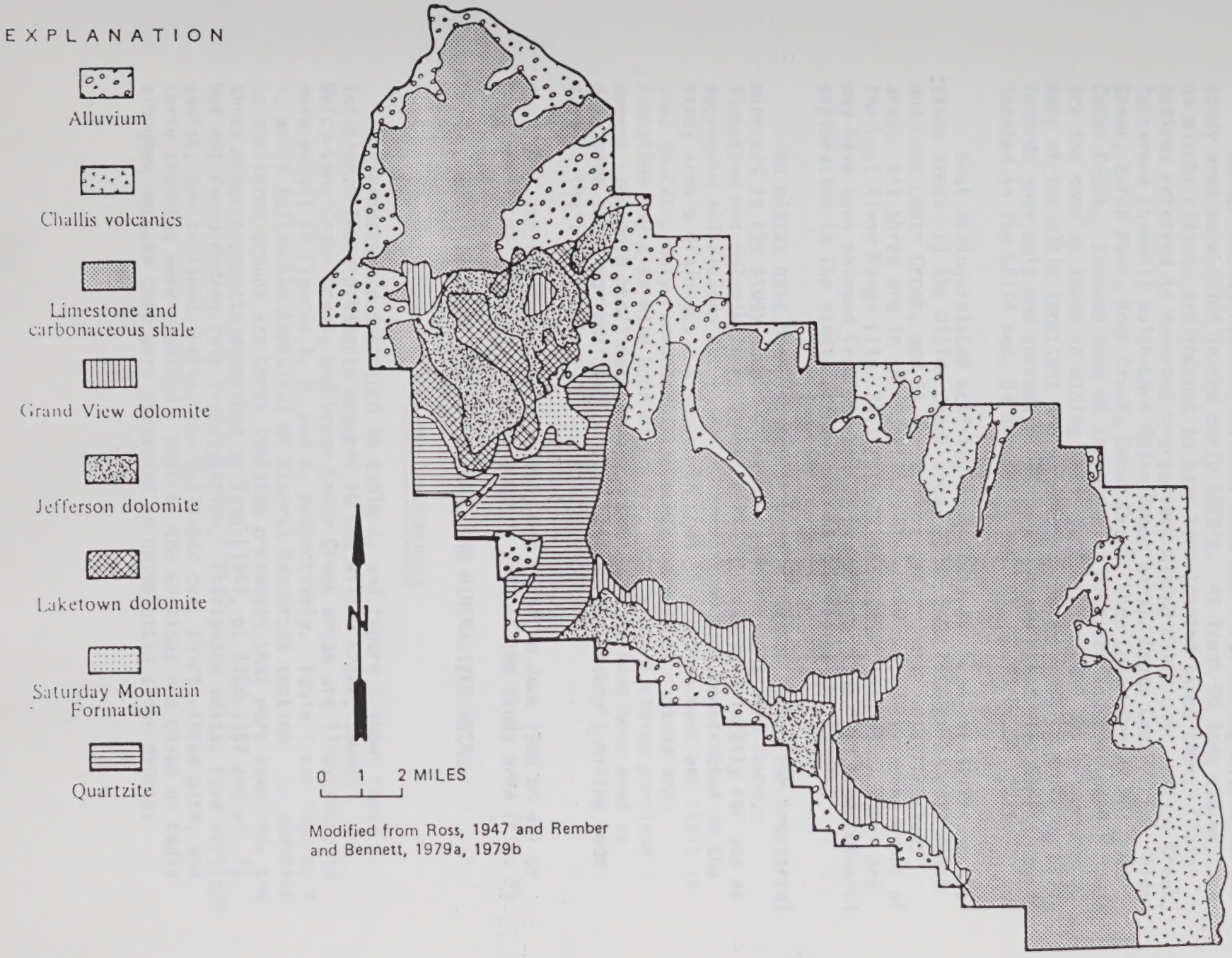
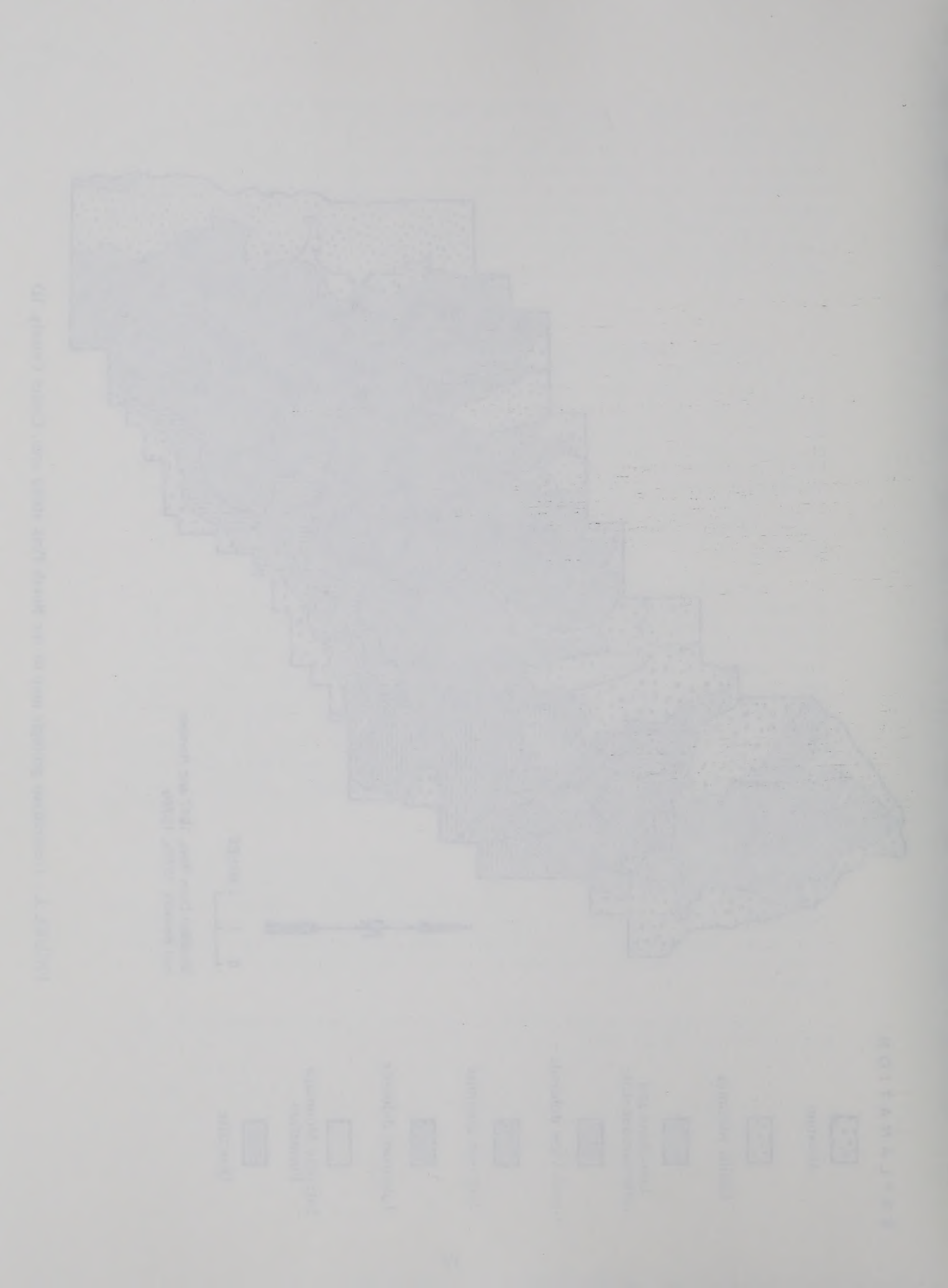


FIGURE 3.-- Generalized geologic map of the Borah Peak study area, Custer County, ID



MINING HISTORY

Custer County records indicate that the first mining claims in the study area were filed in the early 1880's. At least 90 lode claims, but no placer claims, are thought to have been located since then. Claim notices referred to numerous unorganized mining districts: Willow Creek, Tuscarora (Sawmill Gulch-Lone Cedar Creek area), Upper Cedar Creek, Alder Creek, Borah Peak, Rock Creek, Cedar Creek, Lone Cedar Creek, and Lower Cedar Creek. Because some of these mining district and topographic names are the same as those in mining areas just west of the Lost River Range, many of the claim locations are uncertain. January 1987 BLM mining claim records show only one current claim in the study area: the Cavity No. 4, located in the SE1/4 sec. 34 and SW1/4 sec. 35, T. 10 N., R. 22 E.

Most mining-related activity took place at three localities in the study area: 1) the Willow Creek area, 2) an area between Sawmill Gulch and Lone Cedar Creek, and 3) where Upper Cedar Creek exits the study area. All three are in the foothills along the southwest-facing front of the Lost River Range (fig. 2). A small tonnage of lead-zinc-silver ore may have been shipped from one or two properties. The last known mineral exploration in the study area was for barite during the 1960's.

No claims have been located or mineral leases issued for industrial minerals in the study area. Although no excavations were found, limestone and dolomite were almost certainly quarried locally for use as aggregate and rip-rap for power and irrigation dams constructed in the study area's drainages. A number of small irrigation dams are still in use; however, only remnants of the power dams exist. Study area limestone may also have been mined for locally manufactured portland cement, and both the limestone and dolomite might have been used as dimension stone for building construction during Mackay's mining boom days in the late 1800's.

Oil and gas lease applications were filed in June 1986 on all or parts of 17 sections in the southwestern part of the study area (fig. 2).

MINES, PROSPECTS, CLAIMS, AND MINERALIZED AREAS

Lode Occurrences

Prospects are described in table 1, and figure 2 shows their location. Those prospects grouped in the Willow Creek, Sawmill Gulch-Lone Cedar Creek, and Upper Cedar Creek areas are illustrated in more detail in figures 4, 5, and 6, respectively. Table 1 and figures 4, 5, and 6 follow the Appraisal of Mineral Resources section. In addition to the three groups are three isolated prospects that were examined, and three other prospects described by Ross (1947, p. 1156-1157 and pl. 1) but not found during this investigation. Thirty-one adits, five vertical shafts, two inclined shafts, one bulldozer cut, thirty-three pits, and three trenches were examined. Most of the workings are caved or badly sloughed because they were excavated in unsupported slope debris.

Dolomite

Dolomite is the main constituent of several geologic formations in the study area where it underlies more than 30 mi^2 (fig. 3). Analyses of samples from outside and within the study area (Mapel and others, 1965; Ross, 1947, p. 1118) show some of the dolomite is relatively pure. Their analyses indicate that the Jefferson dolomite.contains the most pure strata, with MgO (magnesia) content ranging from approximately 20 to 22 percent and insoluble contaminants of 2 percent or less.

Sediments at the base of the Jefferson dolomite and the underlying and overlying sediments (the Laketown and Grandview dolomites) contain higher percentages of contaminants and lower percentages of MgO. The Saturday Mountain Formation, which is exposed in the study area on the south side of Borah Peak, has beds of dolomite comparable to those of the Jefferson Formation, but analyses indicate that the beds are interrupted by lower grade dolomites, giving the entire formation a lower MgO content.

Limestone

The Three Forks and Brazer limestones include more than 4,000 vertical feet of limestone that varies from siliceous, to dolomitic, to relatively pure. The limestone is exposed in an area of more than 100 mi^2 within the study area (fig. 3). Analyses of samples from outside and within the study area (Mapel and others, 1965; Ross, 1947, p. 1118) indicate that the Brazer limestone contains strata with as little as 1 percent insoluble contaminants and less than 1 percent MgO, which is an undesirable constituent for some limestone uses. Other beds within the Brazer and Three Forks limestones contain both higher percentages of insoluble contaminants and/or higher percentages of MgO.

APPRAISAL OF MINERAL RESOURCES

Dolomite is the main constituent of several geologic formations within the study area. Analyses of rock in these formations outside the study area (Mapel and others, 1965) combined with geologic maps showing continuity, allow for an inferred reserve base exceeding 1 billion tons of dolomite suitable for metallurgical purposes within the study area. Bennett (1944, p. 6-7) states that ". . . for production of magnesium metal, . . . rock . . . with no more than 3 percent impurities such as silica, iron, and alumina, and with no less than 20 percent magnesia, is preferred." A supplement to Bennett's report (Washington State Division of Geology, 1944) contains analyses of dolomite from an area presently (1987) being mined near Addy, WA, and indicates an average grade of 21.3 percent MgO, with 1.63 percent insoluble contaminants. In 1987, the processing plant at Addy was the only producer of magnesium metal from dolomite in the United States. The Borah Peak study area dolomites fall within these grade parameters.

Limestone comprises most of the core of the study area. Analyses and geologic maps show that an inferred reserve base exceeding 1 billion tons of limestone suitable for a variety of uses exists within the study area. Based on data extrapolated from strata outside the study area (Mapel and others, 1965), some of these same strata in the study area should be of very high purity, less than 1 percent contaminants and 1 percent MgO, and are possibly suitable for high-grade uses. Other strata contain minor contaminants but are suitable for many other uses. Boynton (1980, p. 95-158, 380-486) discusses a variety of uses for limestone and lime, the allowable impurities, and milling requirements. Some of the uses include portland cement, aggregate, slag and fluxes for iron and steel manufacture, glass, pulp, paper, whiting, pigments, and several agricultural uses.

The limestone and dolomite found in the area have been used as rip-rap, aggregate, and possibly for building stone and for the manufacturing of portland cement. This minor, local demand for limestone and dolomite, and for limited amounts of sand and gravel in the study area, could continue in the future; however, occurrences just outside the study area are numerous and of sufficient size to supply demand. Extensive sampling and more detailed mapping would be required to better delineate the dolomite and limestone resources; however, existing geologic maps show large outcrops of these rocks outside the study area.

Lead, silver, and zinc are the principal commodities at the three groups of prospects in the study area. The occurrences are in scattered and discontinuous replacement material along shear zones in carbonate rocks. All of the prospects were found along the western range-front near the Lost River Fault. Any additional metal occurrences, if present in the study area, would most likely be in the same zone and of similar geology. Umpleby (1917, p. 41) in discussing the ore deposits of the Mackay region noted that, "The striking feature in the distribution of the known (base and precious metal) ore deposits in the Mackay region is their absence from the Lost River Range and their wide occurrence elsewhere."

Caving and sloughing precluded extensive sampling of in-place material. Select samples from stockpiles and dumps at the prospects contained as much as 15.2 percent lead, 15.5 oz/ton silver, 1.27 percent zinc, and 4.8 percent copper. (Only one other sample exceeded 1.0 oz/ton silver, and only the one sample exceeded 0.32 percent copper.) Although these concentrations are comparable to operating mines elsewhere, evidence on dumps and at the few accessible vein and pipe-shaped exposures suggests the occurrences are too small and widely scattered to constitute economically minable resources.

Barite (barium sulfate) occurs as an accessory mineral at many of the base metal prospects. However, at the Snowshoe prospect, it was the mineral of primary interest. A select sample from the prospect contained 88 percent barium sulfate, but the mineralized area is too small and the veins are too narrow and irregular to constitute identified resources.

TABLE 1.--Prospects and mineralized areas in the Borah Peak study area, Custer County, ID

Name	Summary	Workings and production	Analytical results
Willow Creek area (fig. 4)	Galena (lead sulfide), sphalerite (zinc sulfide), and minor barite (barium sulfate) occur in scattered, discontinuous alteration and replacement zones and pipes up to 4 ft wide within medium- to dark-gray Paleozoic carbonate rocks. These zones trend roughly west with dips approaching vertical, and are within an irregularly-shaped area elongated about 2,000 ft in an easterly direction with about a 1,100-ft width. The zones are commonly brecciated and limonite-stained, and contain occasional boxwork. Portions of these zones may be silicified or dolomitized; small quartz veins and calcite veins up to about 1/4 in. wide were also observed, and some druzey vugs were noted in the rock. The mineralized area is believed to have been first claimed in 1882 and called the Khedive mine. There have been 30 more claims located in the vicinity since then. The prospected area was most commonly referred to as the Charles Mellin property; he relocated it in 1916 and changed the name to the Morning Star group. In 1928, the group was again reclaimed by him and renamed the Indian Chief and Eagle Nest groups. In 1941, the area was relocated by Ida Lyon as the Mount Borah group. The property was last worked by Floyd Sherry of Mackay, ID, in about 1955. Several claims including the Cavity No. 4 (the only current claim in the study area as of January 1987) have been located on Rock Creek about 1 mi south of this group, but no workings were found in that vicinity.	Twelve workings: one open adit (14 ft long), five caved adits (estimated lengths of 35 ft, 50 ft, 80 ft, 80 ft, and 175 ft), one shaft (caved, of unknown depth), 4 pits, and one short trench. A few tons of lead and zinc ore may have been shipped prior to 1935 (Ross, 1947, p. 1156).	Eight samples (appendix A, nos. 2-8): a trace of gold was found in two samples; silver ranged from 0.1 to 0.4 oz/ton in five; lead ranged from 0.005% to 1.01% in seven, and one sample assayed 15.2%; zinc ranged from 0.027% to 1.27% in four samples; barite ranged from 0.12% to 3.7% in three.

TABLE 1.--Prospects and mineralized areas in the Borah Peak study area, Custer County, ID--Continued

Name	Summary	Workings and production	Analytical results
Sawmill Gulch-Lone Cedar Creek area (fig. 5)	Galena, sphalerite, barite, minor silver and gold, and minor amounts of the secondary copper carbonate minerals azurite and malachite occur in discontinuous alteration and replacement zones. Veins and silicified structures up to about 4 ft wide are found in the zones, and commonly contain narrow barite seams, and usually calcite stringers up to 1 in. thick3 These zones are scattered in irregular groups up to 500 ft across within an elongated northeasterly-trending area about 9,000 ft long by 4,000 ft wide. This area is characterized on a larger scale by shear zones in proximity with the contact between Devonian dolomite and Ordovician or older quartzite. A variety of attitudes were encountered in the structures exposed by the numerous workings, but a crude pattern of primarily northwesterly strikes emerged as dominant in the west, with a less strong pattern of northeasterly strikes in the east. Steeply inclined to near vertical dips were common throughout the area, with south dips slightly more favored. Portions of the prospected area's surface are oxidized to orangish-red. The first claim known to have been located in this area was the Climax Extension in 1882; since that time approximately 45 claims have been located in the vicinity.	Fifty-one workings: 12 open adits (ranging from 20 to 91 ft), 8 caved adits (7 estimated to range from 20 to 150 ft and one which may contain up to 1,000 ft of workings), 4 open vertical shafts (up to 30 ft deep), 2 open inclined shafts (up to 30 ft deep), 23 pits, and 2 trenches. Those adits or pits driven or dug into slope debris were caved or badly sloughed. According to local residents, a few tons of ore may have been produced from one or more of these workings. Ross (1947, p. 1156) described what is believed to be the 75-year-old John Prichett property at the southeast end of the area near Lone Cedar Creek; the size of the dump (which contained dolomite with calcite stringers) indicates workings of up to 1,000 ft and may have been the source of the reported production.	Forty-four samples (appendix A, nos. 12-55): trace levels of gold were found in five samples and one had 0.03 oz/ton; silver ranged from 0.1 to 0.8 oz/ton in 25 samples, with 15.5, 3.1 and 1.1 oz/ton in three others; lead ranged from a trace to 0.58% in 37 samples, one had 14.0% and another had 10.1%; zinc ranged from a trace to 0.23% in 39 samples; copper ranged from a trace to 0.32% in 36 samples, and one had 4.8%; barite ranged from a trace to 25.8% in 26 samples and from 42.5% to 85.0% in five; strontium ranged from 0.0011% to 0.31% in 37 samples; and the one sample analyzed by X-ray fluorescence for tungsten contained 0.01% tungsten trioxide. (The highest concentrations of silver, zinc, and copper were in a select sample of highly altered material on the dump of a caved adit. The source of this material could not be verified; none was found in the open workings or on the dumps of other caved workings in the vicinity.)
Upper Cedar Creek area (fig. 6)	Prospect workings are in scattered and discontinuous altered zones within Jefferson dolomite. No ore minerals were observed. Boxwork limonite, possibly after pyrite, was noted in outcrops and in small piles on dumps. Limonite seams up to 1/2 in. were seen paralleling apparent near-horizontal dolomite bedding; other limonite seams, up to nearly vertical, also crossed this combination. Some of the rock contained thread-size stringers of calcite. Mineralized shears and altered zones up to 8 ft wide and calcite seams up to 2 ft wide trend roughly northeast, with near-vertical dips. Where unaltered, the rock is gray to dark gray and thick bedded. In 1890, the North Star claim was located on the north side of the canyon and was relocated as the Red Oxide group in 1915. In 1927, the Cedar Post claim was located on the opposite side of the canyon.	Nine workings: four caved adits (estimated to be 40 ft, 150 ft, 250 ft, and 350 ft long), and five small badly sloughed pits.	Thirteen samples (appendix A, nos. 56-68): a trace of gold was found in three samples and 0.1 to 0.2 oz/ton silver in eight. Assays showed no significant base metals.

TABLE 1.--Prospects and mineralized areas in the Borah Peak study area, Custer County, ID--Continued

Name	Summary	Workings and production	Analytical results
Big Dyke (?) prospect (fig. 2)	A 10-ft-thick vein of coarsely crystalline calcite, at least 30 ft long, strikes N. 15° W. and dips 67° E. It is covered with talus at either end. The prospect was located by George L. Shoup and others in 1952, probably for optical calcite.	One small pit. No known production.	One select sample (appendix A, no. 1): analysis showed no gold or silver.
Snowshoe prospect (fig. 2)	Barite occurs in the vicinity of the contact between the older quartzite and the Kinnikinic quartzite near Sawmill Gulch. The occurrence is a discontinuous zone of pinching and swelling seams, with various strikes and dips, occurring in an exposed area of about 50 by 50 ft. The seams swell to a maximum of 3 ft but are more commonly about 1 ft wide, and pinch to about 0.1 ft away from the zone of greatest concentration. The prospect consists of claims located by Fred Chaffin and others in the 1960's.	A bulldozer road cuts the structure. No known production.	Three samples (appendix A, nos. 9-11): one sample assayed 88.4% barite. Another sample of barite from the same location yielded a specific gravity of 4.39. A sample taken from a nearby locality in the host rock contained 5.3% barite.
Pass Creek prospect (fig. 2)	Limonite-stained vein quartz was found on a dump comprised of light greenish-gray, sandy-textured tuff. The largest quartz piece was 2 ft in it's longest dimension and 1 ft thick.	Caved adit about 90 ft long strikes N. 25° W. No known production.	One sample (appendix A, no. 69): analysis showed no mineral values.
Jayrock prospect (not found)	According to Ross (1947, p. 1157), "The Jayrock prospect is in a saddle on the crest of the Lost River Range at the head of the cirque in which Pass Lake lies. According to a notice on the claim, it was located July 21, 1934, by L. V. Carothers. It is opened by a short bench about 3 ft deep which follows a mineralized zone that strikes N. 20° E., dips 70° NW., and seems to be about 10 ft wide. The zone is on the contact between rusty, pitted quartzite and dark dolomite and contains vein quartz and abundant limonite. The dark dolomite cannot be traced far because of the abundant talus on both sides of the ridge crest. As it is in a zone of contorted and overthrust beds it might belong either to the Jefferson dolomite or to some much older unit. There are several other places, both in this vicinity and in other parts of the quadrangle, where dolomitic beds associated with the Kinnikinic quartzite contain conspicuous amounts of limonite."		

TABLE 1.--Prospects and mineralized areas in the Borah Peak study area, Custer County, ID--Continued

Name	Summary	Workings and production	Analytical results
Kranovich (not found)	Ross (1947), p. 1157, mentions a prospect in the valley of Wet Creek in the southeast corner of the Borah Peak Quadrangle. He further states that "Most of these prospects [the Kranovich being one of several in the quadrangle] are in the Carboniferous rocks, and the others are in the Three Forks limestone. All show irregular fractures in limestone or limey shale which are in part lined with calcite, limonitic material, and some quartz."		
Massacre Mtn. (not found)	As shown on plate 1 of Ross (1947), a prospect is located about 2 1/2 mi northeast of Massacre Mountain. The geologic description is the same as for the Kranovich.		

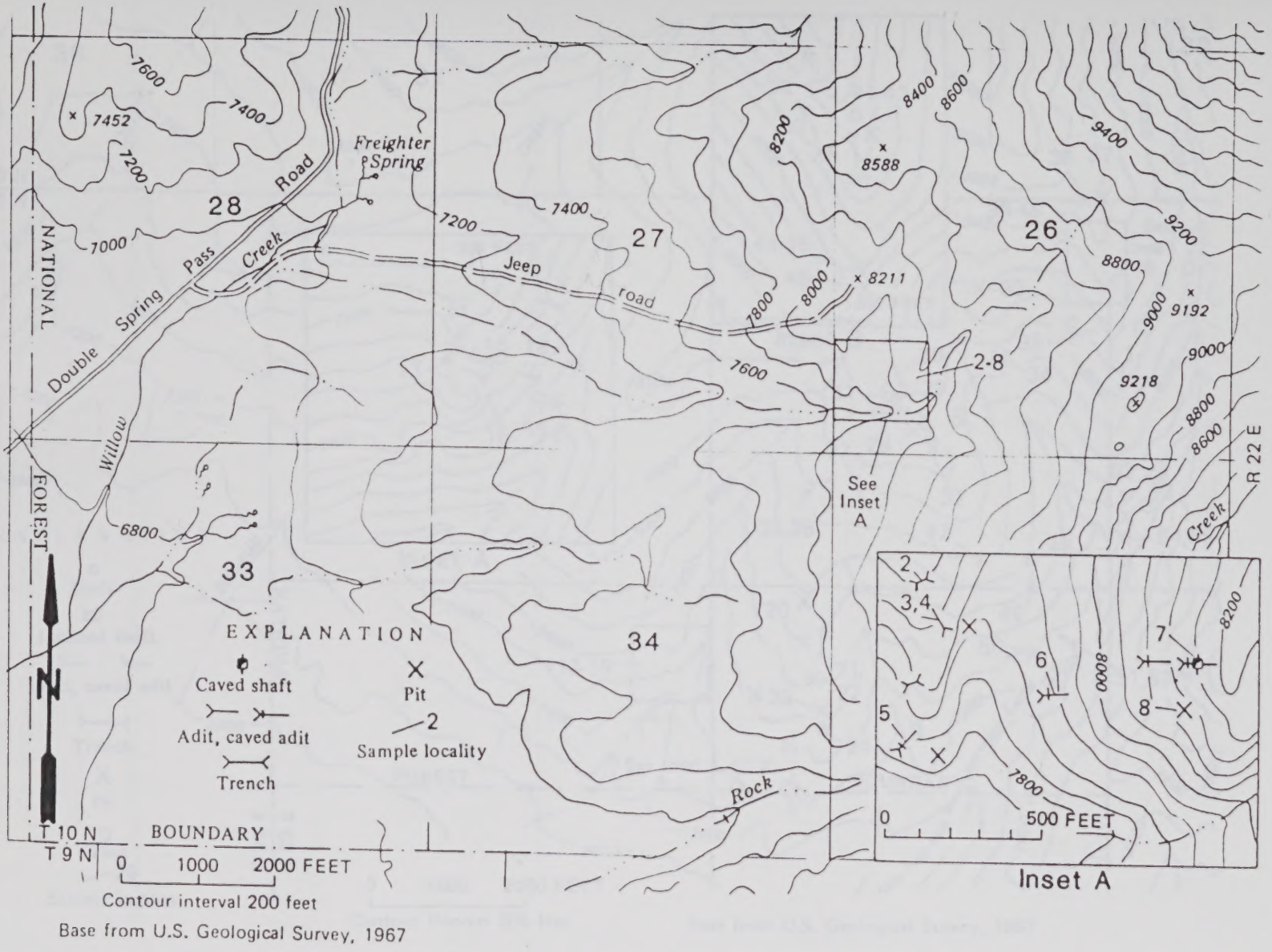


FIGURE 4.– Willow Creek area prospects and sample localities

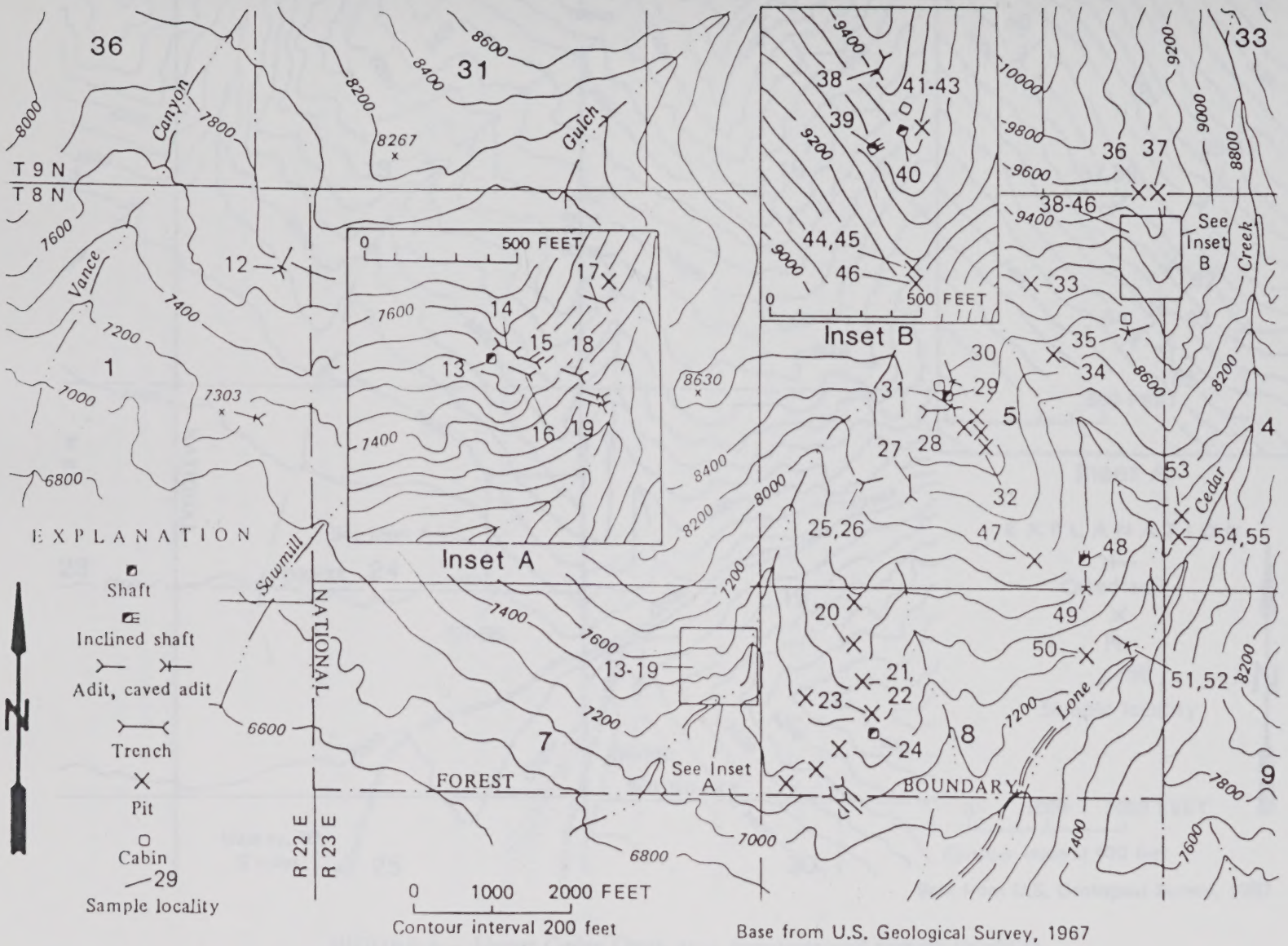


FIGURE 5.– Sawmill Gulch and Lone Cedar area prospects and sample localities

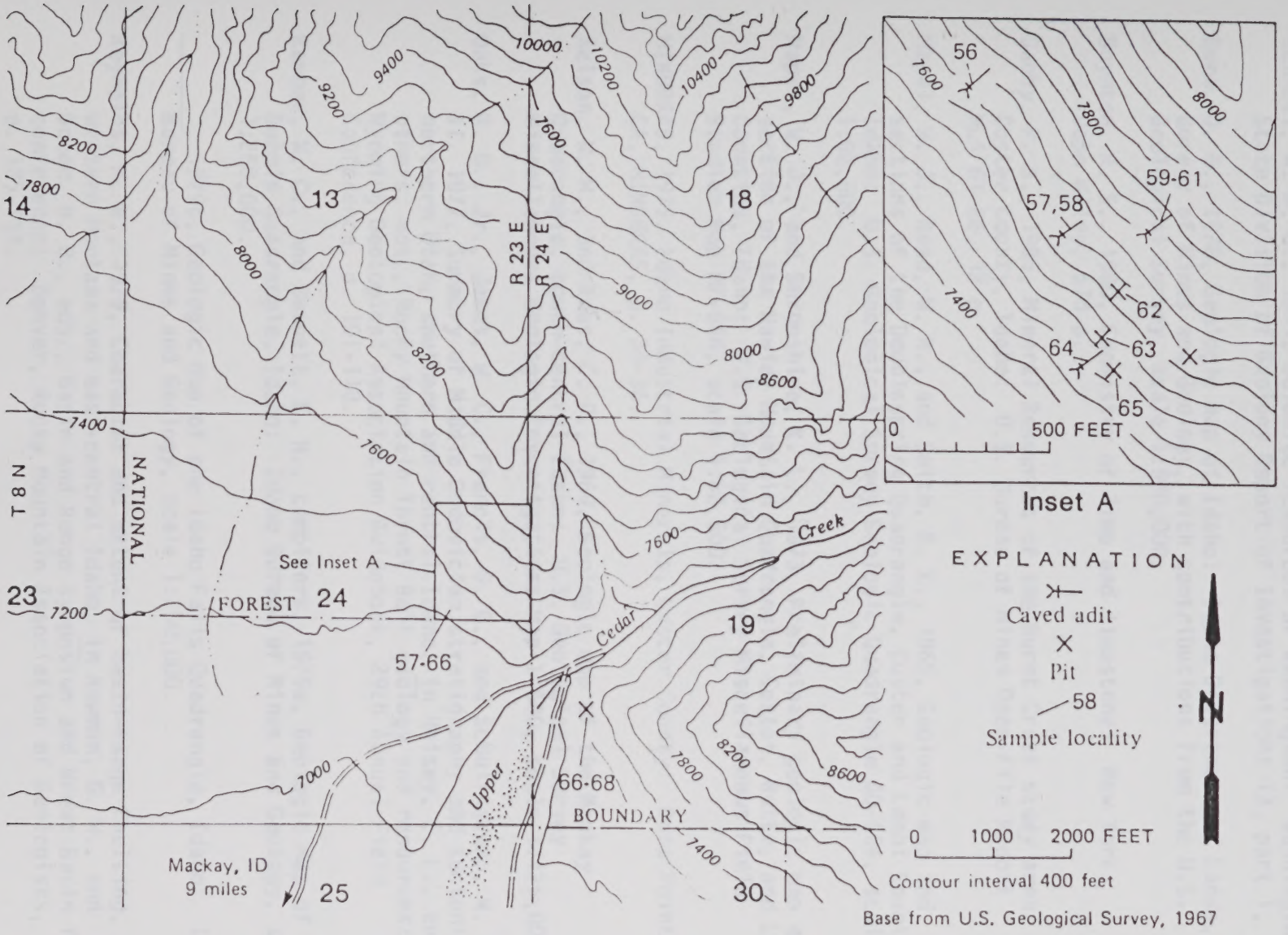


FIGURE 6.– Upper Cedar Creek area prospects and sample localities

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APPENDIX A. - Sample information to accompany Figures 2, 4, 5, and 6, Borah Peak study area, Custer County, ID. (Tr, trace; NA, not applicable; N, none detected; --, not analyzed; *, low value ICP assays shown in Appendix B)

Sample No.	Type	Length (ft)	Description	Gold (oz/ton)	Silver (oz/ton)	Lead (%)	Zinc (%)	Copper (%)	Barite (%)	Tungsten (%)
1	Select	NA	From heavily limonite-stained portion of a coarse-grained 10-ft-wide calcite vein. The vein is at least 30 ft in length but is covered at both ends by talus; strikes N. 15 W., dips about 67 NE.	N	N	--	--	--	--	--
2	Select	NA	From brecciated zones in 15-ft-long trench; zones are perpendicular or sub-parallel to bedding (widest zone is 4 ft wide). Contains limonite-stained calcite coatings.	N	0.2	0.016	0.027	--	--	--
3	Select	NA	From 30-lb stockpile on dump of 14-ft adit. Moderately limonite-stained, slightly-brecciated, dark gray calcareous rock with veinlets up to 1/4 in. wide of quartz and specular hematite.	Tr	N	1.01	.96	--	--	--
4	Chip	1.2	From 14-in-wide shear zone (striking N. 28 W., dipping 88 NE.) at the face of the 14 ft adit. Slightly limonite-stained, moderately brecciated calcareous rock. Bedding trends N. 10 W., dips 39 SW..	Tr	.1	.191	1.27	--	--	--
5	Select	NA	From 2.5-ton stockpile on dump of caved adit oriented N. 40 E., approximately 20 ft long. Silicified/dolomitized matrix with moderate to heavy limonite stain; very vuggy.	N	N	.005	--	--	3.7	--
6	Select	NA	From stockpile of about 100 lb on dump of caved adit oriented N. 85 E., approximately 50 ft long. Brecciated calcareous rock with heavy limonite stain and boxwork; sparse quartz veining.	N	N	.028	--	--	.20	--
7	Select	NA	From 200-lb stockpile on dump of caved adit oriented N. 85 E. and approximately 175 ft long, and a 14-ft--deep shaft. Limonite-stained, brecciated calcareous rock with blebs of quartz and quartz crystals in voids. Contains galena in small acid-etched blebs.	N	.4	15.2	.81	--	--	--
8	Random chip	NA	From 3.5-ft-deep prospect pit. Silicified or dolomitic, heavily limonite-stained, and moderately-vuggy, brecciated calcareous rock.	N	.1	.57	--	--	.12	--

APPENDIX A. - Sample information to accompany Figures 2, 4, 5, and 6, Borah Peak study area, Custer County, ID--Continued.

Sample No.	Type	Length (ft)	Description	Gold (oz/ton)	Silver (oz/ton)	Lead (%)	Zinc (%)	Copper (%)	Barite (%)	Tungsten (%)
9	Select	NA	Veins and seams of barite from 1 to 3 ft thick with trace amounts of malachite and azurite, from a 50-by 50-ft area. The veins and seams pinch to 0.1 ft beyond the area of concentration.	N	N	*	*	0.03	88.4	--
10	Select	NA	Barite sample from the previous location, taken to determine specific gravity. The average of 12 determinations is 4.39 gm/cc.	--	--	--	--	--	--	--
11	Select	NA	Medium grained carbonate host rock of the previous sample. Limonite inclusions are common and limonite pseudomorphs after pyrite cubes up to 0.5 in. were seen.	Tr	0.1	*	*	*	5.3	--
12	Select	NA	From dump of caved adit oriented N. 25° E., approximately 55 ft long. Limonite-filled-and-stained quartz vein material up to 0.1 ft thick.	N	N	--	--	--	--	--
13	Grab	NA	From stockpile of 29-ft-deep shaft. Veinlets of quartz and barite in gray, limey quartzite; contains small pods and smears of malachite and azurite.	N	.5	*	*	.13	42.0	--
14	Random chip	NA	Small discontinuous trench in calcareous rock exposing barite pod near shaft. Barite pod and host calcareous rock exhibit surficial azurite and malachite; secondary quartz growth.	N	.5	--	--	.09	15.0	--
15	Chip	4.0	From 4-ft-wide brown-to-tan shear zone (striking N. 65° W., dipping 75° SW.) containing minor barite veinlets; exposed by a 35-ft-long adit.	N	.1	--	--	--	.3	--
16	Random chip	NA	From roof and face of 20-ft adit exposing pods of quartz and containing minor oxidized pyrite. Fracture planes show dendritic manganese and small black to brown metallic crystals.	N	N	*	*	*	*	--
17	Select	NA	From 54-ft-long adit oriented N. 68° W. Across vertical vein of sugary quartz containing quartz stringers.	N	N	--	--	--	--	--
18	Random chip	NA	From 91-ft-long adit oriented N. 68° W.. Sample was taken along the full length of the adit from a 4-ft-wide brecciated shear zone trending N. 68° W., dipping 55° NE.	N	N	*	*	*	*	--

APPENDIX A. - Sample information to accompany Figures 2, 4, 5, and 6, Borah Peak study area, Custer County, ID--Continued.

Sample No.	Type	Length (ft)	Description	Gold (oz/ton)	Silver (oz/ton)	Lead (%)	Zinc (%)	Copper (%)	Barite (%)	Tungsten (%)
19	Select	NA	From adjoining dumps of two or three caved adits. Material is vuggy, highly altered, and has surface coatings and fracture fillings of azurite; also contains an unidentified black mineral. The dumps have been partially removed by stream action at their bases and possibly represent several hundred feet of workings.	N	15.5	*	0.23	4.8	*	--
20	Select	NA	From 5 by 6 by 4-ft-deep pit. Material is massive white quartz with veinlets and blebs of hematite in purple quartzite country rock.	N	N	*	*	*	*	--
21	Chip	0.9	From small pit. Zone sampled consists of 0.3-ft-wide outcrop of friable, weathered quartzite with an unidentified oxidized mineral and manganese dendrites, and includes 0.3 ft of calcareous host rock on either side.	N	N	*	*	*	*	--
22	Grab	NA	From same location as No. 21. Material consists of gray calcareous host rock with veinlets of quartz and gossan.	N	.1	*	*	*	0.03	--
23	Random chip	NA	From pit. Material consists of extensively altered, very friable, gray calcareous rock with veinlets of quartz and gossan .	N	.1	*	*	*	.4	--
24	Select	NA	From stockpile of a 20-ft-deep shaft following an irregular-shaped pipe of limonite. Material consists of limonite and heavily limonite-stained, calcareous country rock.	N	.1	--	--	--	--	--
25	Chip	0.5	From shear zone trending N. 60° W. and dipping 85° SW. in a 20-ft-long, L-shaped adit. Material consists of lightly to moderately limonite-stained, fractured quartz veinlets and gouge with malachite and azurite.	N	.3	*	*	.05	.05	--
26	Chip	1.5	From same location as No. 25, on the north side of of the shear zone. Material is from repeatedly-fractured-and recemented medium gray quartzite with quartz veins up to 0.1 ft thick in the recemented areas, and minor amounts of malachite and azurite.	N	.4	*	*	.06	.01	--

APPENDIX A. - Sample information to accompany Figures 2, 4, 5, and 6, Borah Peak study area, Custer County, ID--Continued.

Sample No.	Type	Length (ft)	Description	Gold (oz/ton)	Silver (oz/ton)	Lead (%)	Zinc (%)	Copper (%)	Barite (%)	Tungsten (%)
27	Chip	2.0	From shear zone trending N. 65° W., dipping 85° SW. in adit. Material consists of medium gray quartzite and phyllite and fractured quartz and barite veins.	Tr	3.1	*	*	0.32	0.3	--
28	Chip	4.0	From shear zone trending N. 80° W., dipping 58° SW. across the face of 20-ft-long adit. Shear zone contains minor malachite and azurite coatings on fractures. Dump and muck pile contain minor amounts of barite.	N	N	*	*	<.001	.12	--
29	Grab	NA	From dump of 10- by 10-ft shaft 30 ft deep with drift at bottom. Material consists of 0.5-to 0.75-in.-thick barite veinlets in gray quartzite with minor pyrite, malachite coatings, and azurite pods.	N	N	*	*	.006	9.5	--
30	Grab	NA	From pit. Material consists of barite and quartz veins and veinlets up to 0.75 in. wide in friable, argillaceous quartzite with barite and quartz fracture fillings and surface coatings.	0.03	N	*	*	*	.01	--
31	Grab	NA	From short caved adit. Material consists of barite and quartz up to 1 in. wide with 0.25-in. blebs of azurite and surface coatings of azurite and malachite in gray quartzite host rock.	N	N	*	*	.01	.01	--
32	Chip	4.0	From 5- by 5-ft pit 5 ft deep. Material consists of 1.0 ft of barite pod, 0.3 ft of barite vein material, and barite in breccia and blue-gray quartzite host rock.	Tr	N	*	0.10	*	48.0	--
33	Grab	NA	From pit. Material consists of barite and quartz containing chalcopyrite, limonite, and malachite stain in a light gray quartzite host rock.	Tr	N	*	*	.03	68.0	--
34	Grab	NA	From pit. Material consists of secondary, coarse grained, light-brown-to cream-colored calcite veinlets up to 1 in. across in brown, fine grained calcareous host rock.	N	.5	*	*	*	*	--
35	Chip	4.0	From shear zone trending N. 70° E., dipping 70° SE., explored by a 25-ft-long caved adit. Material consists of minor amounts of barite and galena in a limonite-stained shear zone bounded by argillaceous calcareous country rock.	Tr	.2	0.10	*	*	1.9	--

APPENDIX A. - Sample information to accompany Figures 2, 4, 5, and 6, Borah Peak study area, Custer County, ID--Continued.

Sample No.	Type	Length (ft)	Description	Gold (oz/ton)	Silver (oz/ton)	Lead (%)	Zinc (%)	Copper (%)	Barite (%)	Tungsten (%)
36	Chip	2.0	From pit. Material consists of quartz veinlets up to 1 in. thick in calcareous country rock.	Tr	0.3	*	*	*	0.032	--
37	Grab	NA	From pit. Material consists of heavily limonite-stained calcareous rock with minor amounts of quartz.	N	.2	*	*	*	*	--
38	Chip	4.5	Do	N	1.1	*	*	*	*	--
39	Grab	NA	From dump of 30-ft-deep inclined shaft. Material includes 3-to 6-in.-thick veins of calcite, quartz, and galena.	N	.8	14.0	*	*	*	--
40	Grab	NA	From dump of 15-ft-deep shaft. Material consists of barite, quartz, and galena from a shear zone trending N. 70° E., dipping 85° SE., in brecciated and silicified, fetid calcareous rock.	N	.3	.58	*	*	25.8	--
41	Grab	NA	From pit. Material consists of 2-to 5-in.-thick stringer of silicified calcareous rock along a shear zone trending N. 20° W., dipping 20° NE.	N	.8	10.1	*	*	*	--
42	Grab	NA	Sidecast material from previous pit. Material consists of 3-to 4-in.-thick vein quartz with minor galena.	N	.2	.04	*	*	*	--
43	Chip	2.1	Across fracture zone at same pit. Material consists of silicified calcareous rock, quartz, and a banded, fine-grained, dark mineral in a zone trending N. 20° W., dipping 70° NE.	N	.2	*	*	*	*	--
44	Chip	0.8	From pit. Sample from across a barite lens exposed for approximately 6 ft in medium-grained gray calcareous rock.	N	.3	*	*	*	85.0	<0.01
45	Chip	1.5	From same pit. Material is slightly altered calcareous rock with veinlets of white quartz and minor limonite stain along fractures. Host rock is fine-to medium-grained, gray to brown calcareous rock.	N	.1	*	*	*	1.1	--
46	Chip	2.3	From pit. Material from across a barite and quartz lens exposed for approximately 6 ft in medium-grained gray calcareous rock.	N	.1	*	*	*	42.5	--

APPENDIX A. - Sample information to accompany Figures 2, 4, 5, and 6, Borah Peak study area, Custer County, ID--Continued.

Sample No.	Type	Length (ft)	Description	Gold (oz/ton)	Silver (oz/ton)	Lead (%)	Zinc (%)	Copper (%)	Barite (%)	Tungsten (%)
47	Grab	NA	From pit. Material includes white quartz cryatals up to 0.1 in. wide, and blue-gray quartzite with quartz and calcite veinlets.	N	0.1	*	*	*	0.2	--
48	Chip	3.0	From 20-ft inclined shaft. Material includes limonite-stained boxwork of quartz, and calcite vein trending N, dipping 85° W. in argillaceous calcareous rock.	N	N	*	*	*	*	--
49	Chip	2.0	Do	N	N	*	0.15	*	*	--
50	Grab	NA	From a 10 ft by 10 ft pit. Material consists of heavily limonite-stained, vuggy, silicified calcareous rock.	N	.2	0.17	*	*	*	--
51	Select	NA	From dump of caved adit estimated to be 300 ft long, trending N. 60° W. Material consists of lightly-to moderately-limonite-stained calcareous rock.	N	N	.003	.001	--	--	--
52	Select	NA	From same dump as previous sample. Material consists of dark calcareous rock containing multiple veins and stringers of calcite in fractures.	N	.1	<.003	.001	--	--	--
53	Chip	0.5	From pit. Sample from across white, striated material exposed for 10 ft along bedding trend of N. 50° W. and dipping 50° NE. in argillaceous calcareous rock.	N	.7	*	*	*	.05	--
54	Chip	1.0	From pit. Material consists of banded limonite and hematite vein trending N. 35° W., dipping 85° SW., in calcareous rock.	N	.2	.17	.19	*	*	--
55	Chip	3.1	From pit. Material similar to previous sample, along same vein.	N	N	*	.21	*	*	--
56	Select	NA	From 300-lb stockpile on dump of approximately 20-ft-long caved adit trending N. 55° E. Material consists of heavily limonite-stained quartz and calcite boxwork vein in medium to dark gray calcareous rock.	N	.1	.049	.003	0.004	--	--
57	Chip	1.0	From vein trending N. 45° E., dipping 72° SE., at portal of caved adit estimated to be 100 ft long. Material consists of heavily limonite-stained calcite vein with minor boxwork and dark gray calcareous country rock.	Tr	N	--	--	--	--	--

APPENDIX A. - Sample information to accompany Figures 2, 4, 5, and 6, Borah Peak study area, Custer County, ID--Continued.

Sample No.	Type	Length (ft)	Description	Gold (oz/ton)	Silver (oz/ton)	Lead (%)	Zinc (%)	Copper (%)	Barite (%)	Tungsten (%)
58	Select	NA	From stockpile on dump of caved adit at previous sample location. Material is similar to previous sample.	N	0.2	--	--	--	--	--
59	Chip	2.7	From portal of caved adit estimated to be 30 ft long trending N. 35° E. Material consists of heavily limonite-stained, dark gray, brecciated calcareous rock and dark brown limonite bands in a shear zone approximately 5 ft wide.	N	.1	--	--	--	--	--
60	Chip	2.0	From same location. Sample includes 1 ft of dark gray, brecciated calcareous rock from either side of the limonite-stained zone of the previous sample.	N	N	--	--	--	--	--
61	Select	NA	From 400-lb stockpile on dump of caved adit at previous sample location. Material consists of gossan with minor boxwork.	N	.1	0.07d	0.003	0.003	0.015	--
62	Select	NA	From dump of 10 ft by 30 ft by 1-ft-deep pit. Material consists of gossan with minor boxwork.	N	N	--	--	--	--	--
63	Select	NA	From small stockpile near pit. Material consists of gossan with minor boxwork.	Tr	.1	--	--	--	--	--
64	Select	NA	From small stockpile near caved adit estimated to be 30 ft long and trending N. 50° E. Material consists of gossan with minor boxwork.	N	.1	--	--	--	--	--
65	Select	NA	From small stockpile near pit. Material consists of gossan with minor boxwork.	N	.1	--	--	--	--	--
66	Chip	2.0	From across an 8 ft by 20 ft pit. Material consists of recemented, moderately limonite-stained, brecciated, dark gray calcareous rock.	N	.1	--	--	--	--	--
67	Chip	2.5	Continuation of previous sample across an 8-ft pit. Material consists of limonite-stained shear zone with high calcite content.	N	N	--	--	--	--	--

APPENDIX A. - Sample information to accompany Figures 2, 4, 5, and 6, Borah Peak study area, Custer County, ID--Continued.

Sample No.	Type	Length (ft)	Description	Gold (oz/ton)	Silver (oz/ton)	Lead (%)	Zinc (%)	Copper (%)	Barite (%)	Tungsten (%)
68	Chip	3.5	Continuation of previous sample across an 8-ft pit. Material consists of dark gray, brecciated calcareous rock recemented with stringers of calcite.	Tr	N	--	--	--	--	--
69	Grab	NA	From dump of large pit or caved adit. Material consists of light greenish-gray, sandy-textured tuff with no obvious mineralization.	N	0.1	0.005	0.007	0.001	0.2d	--

APPENDIX B. - Inductively coupled plasma (ICP) analyses to accompany Figures 2, 4, 5, and 6 Borah Peak study area, Custer County, ID
(all analyses in ppm unless otherwise stated; <, less than; >, greater than; --, not analyzed)

SAMPLE	ELEMENT							
NUMBER	AG	AL	AS	BA	BE	BI	CA	CD
10	<5	0.13%	<30	0.24%	<0.1	<30	0.49%	<0.4
12	<5	5.5%	200	1.1%	2.5	<30	2.6%	.94
14	12	.19%	160	.40%	<.1	<30	22.7%	.62
17	<5	.10%	<30	260	<.1	<30	32.7%	.75
19	<5	.71%	71	.45%	<.1	<30	38.0%	.45
20	150	1.2%	.30%	210	<.1	660	2.3%	65
21	<5	.64%	35	210	<.1	<30	.17%	<.4
22	<5	13.1%	310	320	<.1	<30	.67%	<.4
23	<5	.51%	84	220	<.1	<30	21.6%	8.2
24	<5	.67%	120	.27%	<.1	<30	25.6%	4.9
26	9.0	1.4%	110	580	1.3	36	18.3%	3.6
27	15	.22%	77	860	.79	63	21.7%	4.6
28	90	.10%	240	.21%	<.1	<30	35.1%	7.8
29	<5	240	<30	640	<.1	<30	34.0%	<.4
30	<5	260	<30	.32%	<.1	<30	29.0%	<.4
31	<5	970	<30	170	<.1	<30	21.4%	<.4
32	<5	660	<30	130	<.1	<30	17.1%	<.4
33	<5	.16%	<30	.26%	<.1	<30	12.2%	2.6
34	<5	.40%	49	1.7%	<.1	<30	.30%	<.4
35	18	.19%	.47%	1.9%	1.3	<30	23.6%	2.3
36	5.9	7.9%	.16%	900	4.6	<30	7.5%	.86
37	9.5	.22%	.27%	250	<.1	<30	13.5%	<.4
38	5.4	8.8%	.13%	.17%	2.9	<30	2.1%	3.6
39	12	14.1%	.14%	.25%	4.3	34	2.3%	6.2
40	27	.43%	290	400	.22	<30	1.4%	.75
41	<5	.33%	<30	.10%	.29	<30	5.4%	.57
42	27	.21%	<30	50	.12	<30	4.9%	1.8
43	<5	630	<30	1.1%	<.1	<30	.44%	<.4
44	7.7	.20%	<30	1.5%	.81	39	20.7%	2.0
45	<5	740	<30	.21%	<.1	<30	1.4%	<.4
46	8.0	.27%	<30	.63%	.77	36	20.6%	2.1
47	<5	780	<30	960	.22	<30	10.3%	<.4
48	<5	.18%	<30	.11%	<.1	<30	11.0%	<.4
49	<5	.83%	190	.44%	50	200	.29%	41
50	<5	2.3%	290	.43%	46	120	.67%	26
51	<5	1.2%	370	580	55	200	.29%	44
54	24	200	57	610	1.0	120	38.3%	5.3
55	<5	.25%	540	550	55	220	.55%	53
56	<5	1.3%	160	190	53	230	.33%	52

APPENDIX B. - Inductively coupled plasma (ICP) analyses to accompany Figures 2, 4, 5, and 6 Borah Peak study area, Custer County, ID--Continued

SAMPLE NUMBER	ELEMENT							
	CO	CR	CU	FE	K	LA	LI	MG
10	<1	11	340	0.32%	0.10%	<4		0.21%
12	<1	41	39	1.1%	4.1%	62		1.4%
14	<1	5.9	.13%	.72%	.12%	<4	<3	.47%
17	<1	16	11	2.2%	990	<4	<3	15.9%
19	<1	14	310	1.3%	.40%	<4	<3	8.0%
20	<1	46	4.8%	.93%	.62%	<4	<3	.29%
21	<1	150	8.7	1.9%	.18%	<4	<3	640
22	23	140	43	.82%	.12%	69	52	.15%
23	<1	17	35	15.1%	.12	4.7	<3	10.3%
24	<1	18	18	8.7%	.27%	<4	<3	12.1%
26	6.6	75	460	1.4%	.63%	23		10.4%
27	5.1	40	580	.78%	.13%	27		12.1%
28	<1	10	.32%	1.5%	810	<4	<3	12.4
29	<1	12	<6	.59%	460	<4	<3	14.2%
30	<1	34	60	1.2%	490	<4	<3	13.9%
31	<1	63	24	.90%	820	<4	<3	10.4%
32	<1	52	120	.91%	660	<4	<3	8.4%
33	<1	4.6	10	1.7%	910	<4	<3	4.8%
34	<1	46	340	.38%	.19%	<4	<3	.13%
35	<1	59	160	1.8%	.12%	18	<3	9.2%
36	5.4	130	11	2.5%	3.9%	20	8.5	3.8%
37	<1	120	<6	.22%	580	<4	4.3	7.3%
38	21	76	64	4.7%	.13%	58	36	.93%
39	23	170	120	6.2%	660	100	120	1.3%
40	<1	160	12	.35%	.12%	<4	<3	.83%
41	<1	95	<6	.22%	570	<4		2.0%
42	<1	100	<6	.18%	540	<4		2.8%
43	<1	21	<6	570	150	<4		.26%
44	<1	38	<6	.33%	420	18		11.6%
45	<1	5.6	<6	490	270	<4		.77%
46	1.2	33	<6	.30%	980	18		12.1%
47	<1	17	<6	.11%	320	<4		6.6%
48	<1	71	<6	.21%	790	<4	<3	5.0%
49	16	53	320	--	780	48		.26%
50	69	84	340	--	.38%	79		.32%
51	34	53	140	--	.58%	48		.45%
54	9.0	38	11	780	530	55		.37%
55	16	45	9.7	--	710	48		.48%
56	17	59	14	--	.55%	52		.63%

APPENDIX B. - Inductively coupled plasma (ICP) analyses to accompany Figures 2, 4, 5, and 6 Borah Peak study area, Custer County, ID--Continued

SAMPLE NUMBER	ELEMENT							
	MN	MO	NA	NB	NI	P	PB	SB
10	110	<5	100	<2	6.5	<100	<10	<30
12	840	26	.17%	93	7.9	310	22	39
14	960	6.3	69	<2	<3	760	<10	330
17	.14%	7.5	840	<2	<3	290	<10	<30
19	800	6.0	200	<2	<3	650	<10	37
20	430	11	120	<2	<3	390	64	.47%
21	26	18	130	<2	<3	<100	<10	<30
22	22	5.9	96	23	32	.23%	<10	<30
23	250	17	180	<2	25	450	120	<30
24	310	26	310	<2	28	140	140	<30
26	870	12	970	<2	28	670	26	220
27	710	13	620	<2	13	370	38	220
28	750	<5	180	<2	<3	120	250	.13%
29	.21%	<5	210	<2	<3	<100	<10	<30
30	.17%	5.5	230	<2	<3	<100	<10	<30
31	.11%	12	200	<2	<3	<100	<10	<30
32	900	9.3	190	<2	<3	<100	<10	36
33	210	<5	130	<2	<3	<100	840	<30
34	110	9.3	190	<2	<3	<100	<10	<30
35	.14%	<5	220	41	7.7	180	280	31
36	420	<5	360	15	17	360	950	<30
37	350	<5	160	21	<3	<100	46	<30
38	130	<5	75	19	20	.27%	100	<30
39	58	<5	260	32	26	.51%	160	96
40	52	13	89	3.2	<3	130	14.0%	<30
41	170	13	110	<2	4.0	<100	.58%	<30
42	130	15	120	<2	<3	<100	10.1%	<30
43	17	<5	<30	<2	<3	<100	440	<30
44	320	9.3	300	<2	12	120	200	<30
45	44	<5	80	<2	<3	<100	<10	<30
46	380	7.7	410	<2	8.4	150	70	<30
47	190	<5	230	<2	8.9	<100	<10	<30
48	100	9.8	98	<2	<3	<100	<10	<30
49	210	31	190	7.8	82	.48%	110	<30
50	620	28	180	4.7	290	.76%	100	<30
51	680	110	230	6.0	250	490	.17%	<30
54	130	22	170	<2	16	300	150	<30
55	170	48	200	5.1	38	340	.17%	<30
56	780	60	240	8.9	48	440	220	<30

APPENDIX B. - Inductively coupled plasma (ICP) analyses to accompany Figures 2, 4, 5, and 6 Borah Peak study area, Custer County, ID--Continued

SAMPLE	ELEMENT								
NUMBER	SN	SR	TE	TI	V	W	Y	ZN	ZR
10	<2	630	<20	15	<5	<30	<1	22	<10
12	6.3	470	<20	590	16	70	15	21	27
14	13	0.27%	<20	39	<5	<30	15	210	<10
17	33	95	<20	36	20	<30	4.4	110	<10
19	26	270	<20	60	16	<30	5.9	120	<10
20	<2	25	<20	100	7.5	<30	3.7	0.23%	14
21	5.4	38	<20	85	<5	<30	<1	63	<10
22	<2	130	<20	0.83%	160	46	21	120	220
23	<2	49	<20	110	30	<30	2.7	190	13
24	13	82	<20	170	40	<30	2.6	300	13
26	25	100	30	470	75	36	9.9	140	28
27	34	85	63	41	52	39	7.9	130	18
28	30	120	<20	16	13	<30	4.1	290	<10
29	35	100	<20	8.4	17	<30	2.4	90	<10
30	37	990	<20	14	17	<30	2.3	130	<10
31	34	100	<20	18	14	<30	1.7	120	<10
32	24	100	<20	21	12	<30	1.2	130	<10
33	19	0.15%	<20	48	6.3	<30	<1	0.10%	<10
34	5.3	0.24%	<20	49	<5	<30	1.1	57	<10
35	16	0.11%	49	26	36	<30	9.1	73	<10
36	<2	140	<20	0.10%	97	<30	16	51	59
37	16	45	29	67	28	<30	3.1	44	<10
38	<2	120	<20	0.78%	230	30	35	81	290
39	<2	400	<20	1.3%	340	80	35	170	330
40	4.9	650	<20	110	7.2	<30	<1	170	<10
41	6.4	0.12%	<20	46	18	<30	1.8	58	<10
42	11	67	<20	26	18	<30	<1	49	<10
43	<2	750	<20	12	<5	<30	<1	17	<10
44	31	350	55	48	50	<30	6.1	62	<10
45	2.0	0.10%	<20	13	<5	<30	<1	16	<10
46	30	320	51	93	50	<30	5.8	50	<10
47	14	0.31%	<20	22	27	<30	2.6	27	<10
48	8.6	67	<20	47	5.0	<30	<1	74	<10
49	43	47	280	100	300	38	8.6	840	42
50	27	460	160	450	210	32	25	0.15%	38
51	42	20	280	270	87	46	6.2	340	57
54	23	270	150	<3	36	79	12	84	16
55	50	15	280	61	70	<30	2.5	0.19%	45
56	51	11	290	300	88	39	4.4	0.21%	57

APPENDIX C. - Semi-quantitative spectrographic analyses to accompany Figures 2, 4, 5, and 6 Borah Peak study area, Custer County, ID
(all analyses reported in %; <, less than; >, greater than)

ELEMENT	SAMPLE NUMBER														
	1	2	3	4	5	6	7	8	9	13	15	16	18	25	52
AG	<.003	<.002	.01	<.005	<.004	<.01	.02	<.01	.02	<.01	<.002	<.004	<.001	<.02	<.001
AL	.2	.3	.3	.2	.7	>3.	.4	.7	.1	.6	.8	>3.	.9	.2	.9
AS	<.009	<.03	<.01	<.03	<.02	<.05	<.009	<.02	<.009	<.07	<.01	<.009	<.009	.07	<.03
AU	<.002	<.002	<.003	<.002	<.002	<.002	<.002	<.003	<.003	<.002	<.002	<.002	<.002	<.002	<.002
B	<.003	<.005	<.01	<.004	<.005	<.005	<.005	.02	.009	<.003	<.004	<.005	<.003	<.01	<.005
BA	<.002	.5	1.	.4	.3	.5	.8	.5	.1	.01	>10.	.5	.01	.08	>10.
BE	<.0001	.0004	.002	.0005	<.0001	.001	.001	.003	.001	.002	<.0001	.0006	<.0001	.0004	.0004
BI	<.01	<.01	<.03	<.01	<.01	<.02	<.08	<.01	<.08	<.01	<.01	<.01	<.01	.1	<.01
CA	>10.	>10.	.3	>10.	10.	2.	<.05	.2	1.	.2	>10.	6.	>10.	<.06	10.
CD	<.0005	<.0005	<.0008	<.0005	<.0005	<.0005	<.001	<.001	<.004	<.0005	<.0005	<.0005	<.0005	<.0005	<.0005
CO	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	.01	<.001
CR	<.0003	<.0003	<.001	<.0003	<.0003	<.0005	.002	.003	.001	<.0003	<.0003	.02	<.0003	.001	<.0003
CU	<.0006	<.0006	.003	<.0006	<.0006	<.0006	.06	.03	.04	<.0006	.09	.001	<.0006	.001	<.0006
FE	3.	2.	10.	2.	1.	2.	10.	>10.	10.	>10.	1.	4.	3.	>10.	2.
GA	<.0002	<.0002	<.0002	<.0002	<.0002	<.0002	.006	<.0005	<.0002	<.0002	<.0002	<.0002	<.0002	.003	<.0002
K	<.6	4.	<2.	7.	6.	>10.	2.	5.	4.	10.	5.	10.	<.6	<1.	5.
LA	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01
LI	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002
MG	.4	>10.	.4	>10.	>10.	>10.	.3	.4	2.	.7	1.	3.	>10.	.6	3.
MN	.02	.1	<.008	.1	.07	.08	<.0008	.05	.03	.05	.03	>2.	.6	.05	.06
MO	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
NA	<.3	<.3	<1.	<.6	<.3	3.	<.3	<.3	<9.	<.3	<.3	<.3	<.3	<.3	<.3
NB	<.007	<.007	<.007	<.007	<.007	<.007	<.007	<.007	<.007	<.007	<.007	<.007	<.007	<.007	<.007
NI	.002	<.0004	<.005	<.0006	.001	.0008	<.0002	<.0006	<.0003	<.0002	<.0004	.01	.001	.03	<.0004
P	<.7	<.7	<.7	<.7	<.7	<.7	<1.	<3.	<1.	<2.	<.7	<.7	<.7	<1.	<.7
PB	<.002	.2	2.	.2	<.002	<.002	9.	.1	.9	.03	<.002	<.002	<.002	.05	<.002
PD	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
PT	<.0006	<.0006	<.0006	<.0006	<.0006	<.0008	<.001	<.0006	<.002	<.001	<.0006	<.0006	<.0006	<.002	<.0006
SB	<.06	<.06	<.08	<.06	<.06	<.06	<.2	<.06	<.1	<.06	<.06	<.06	<.06	<.3	<.06
SC	<.0004	<.0004	<.0004	<.0004	<.0004	<.0004	<.0004	<.0004	<.0004	<.0004	<.0004	<.0004	<.0004	<.0004	<.0004
SI	.3	>10.	>10.	>10.	>10.	>10.	>10.	>10.	>10.	>10.	5.	>10.	.2	3.	>10.
SN	<.001	<.0006	<.007	<.001	<.0006	<.0007	<.002	<.01	<.002	<.01	<.0006	<.003	<.0006	.05	<.0006
SR	.003	<.0001	.0002	.0001	<.0001	.03	.0003	<.0001	<.0001	<.0001	.1	.01	.0004	<.0001	.005
TA	<.02	<.02	<.02	<.02	<.02	<.02	<.02	<.02	<.03	<.02	<.02	<.02	<.02	<.02	<.02
TE	<.04	<.04	<.05	<.04	<.04	<.04	<.04	<.1	<.04	<.04	<.04	<.04	<.04	<.04	<.04
TI	<.03	<.03	<.03	<.03	<.03	<.07	<.04	<.03	<.03	<.03	<.03	.2	<.03	<.2	<.03
V	<.005	<.005	<.005	<.005	<.005	<.005	<.005	<.005	<.009	<.005	<.005	<.005	<.005	.04	<.005
Y	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001
ZN	.02	>10.	1.	>10.	.2	.02	.9	.6	>6.	.002	.01	.003	.001	.02	.1
ZR	<.003	<.003	<.003	<.003	<.003	<.003	<.003	<.005	<.003	<.003	<.003	<.003	<.003	.02	<.003

APPENDIX C. - Semi-quantitative spectrographic analyses to accompany Figures 2, 4, 5, and 6 Borah Peak study area, Custer County, ID--Con.

ELEMENT	SAMPLE NUMBER														
	53	57	58	59	60	61	62	63	64	65	66	67	68	69	70
AG	<.002	<.003	<.005	<.008	<.004	<.01	<.004	<.02	.0005	<.01	<.01	<.003	<.01	<.01	<.006
AL	.9	.2	1.	.3	.8	.6	.2	.6	.6	.6	.6	.2	.6	>4.	.8
AS	<.009	<.009	<.06	<.009	<.07	<.02	<.009	<.04	<.04	<.009	<.05	<.009	<.03	<.01	<.05
AU	<.002	<.002	<.003	<.002	<.005	<.002	<.002	<.002	<.002	<.004	<.004	<.002	<.002	<.002	<.002
B	<.003	<.003	<.003	<.003	<.003	<.004	<.003	<.003	<.003	<.01	<.02	<.003	<.003	<.004	<.007
BA	.03	.005	.02	<.002	.02	.02	<.002	.05	.08	.02	.005	>.002	.8	.4	>10.
BE	<.0001	<.0001	.003	<.0001	.002	.0003	<.0001	.001	.001	.001	.002	<.0001	<.0001	.001	.0008
BI	<.01	<.01	<.02	<.01	<.01	<.03	<.01	.09	.08	<.04	<.01	<.01	<.01	<.01	<.01
CA	>10.	>10.	.4	>10.	<.05	4.	>10.	<.05	.3	<.05	.2	>10.	>10.	2.	5.
CD	<.0005	<.0005	<.0005	<.0005	<.0005	<.0005	<.0005	<.0005	<.0005	<.0005	<.0005	<.0005	<.0005	<.0005	<.0005
CO	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.002	<.001	<.001	<.001	<.001	<.001	<.001	<.001
CR	<.0003	<.0003	<.0003	<.0003	<.0003	<.0005	<.0003	.001	.001	<.0003	<.0003	<.0003	<.0003	.003	<.0003
CU	<.0006	<.0006	<.0006	<.0006	<.0006	<.0006	<.0006	.002	.001	<.0006	<.0006	<.0006	<.0006	.002	<.0006
FE	.9	.5	>10.	1.	>10.	8.	2.	>10.	>10.	>10.	>10.	.6	1.	6.	4.
GA	<.0002	<.0002	<.0002	<.0002	<.0003	<.0002	<.0002	<.0008	<.0005	<.001	<.0002	<.0002	<.0002	<.0002	<.0002
K	4.	2.	>10.	<.6	>10.	5.	<2.	3.	7.	6.	>10.	<.6	6.	>10.	7.
LA	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01
LI	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002	<.002
MG	>10.	>10.	1.	3.	1.	>10.	>10.	1.	2.	1.	1.	>10.	>10.	2.	2.
MN	.09	.03	.09	.2	.1	.2	.4	<.02	.06	.08	.07	.09	.2	.8	.04
MO	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
NA	<.3	<.3	<.3	<.3	<.3	<.3	<.3	<.3	<.3	<.3	<.3	<.3	<.3	<.3	<.3
NB	<.007	<.007	<.007	<.007	<.007	<.007	<.009	<.007	<.007	<.007	<.007	<.009	<.007	<.007	<.007
NI	<.0004	<.0004	<.008	.001	<.008	<.0008	<.0005	<.02	<.01	<.01	<.01	<.0005	.002	.003	.002
P	<.7	<.7	<3.	<.7	<3.	<.7	<.7	<.9	<1.	<.7	<3.	<.7	<.7	<.7	<.7
PB	<.002	<.002	<.007	<.002	.01	<.009	<.002	.01	.02	.01	.02	<.002	<.002	<.002	<.004
PD	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
PT	<.0006	<.0006	<.002	<.0006	<.002	<.0006	<.0006	<.003	<.002	<.0006	<.0007	<.0006	<.001	<.0006	<.0006
SB	<.06	<.06	<.06	<.06	<.06	<.06	<.06	<.2	<.2	<.2	<.06	<.06	<.06	<.06	<.06
SC	<.0004	<.0004	<.0004	<.0004	<.0004	<.0004	<.0004	<.0004	<.0004	<.0004	<.0004	<.0004	<.0004	<.0004	<.0004
SI	>10.	.8	>10.	1.	>10.	>10.	1.	5.	>10.	>10.	>10.	1.	2.	>10.	>10.
SN	<.0006	<.0006	<.008	<.0006	<.03	<.006	<.001	<.002	<.008	<.05	<.009	<.001	<.003	<.0006	<.0006
SR	.0006	<.0001	<.0001	.002	<.0001	<.0001	.0001	<.0001	<.0001	<.0001	<.0001	.001	.0003	.003	.06
TA	<.02	<.02	<.02	<.02	<.02	<.02	<.02	<.1	<.08	<.09	<.02	<.02	<.02	<.02	<.02
TE	<.04	<.04	<.04	<.04	<.06	<.04	<.04	<.04	<.04	<.04	<.06	<.04	<.04	<.04	<.04
TI	<.03	<.03	<.03	<.03	<.03	<.03	<.03	.1	.1	<.05	<.03	<.03	<.03	.2	<.03
V	<.005	<.005	<.005	<.005	<.005	<.005	<.005	.03	.02	<.007	<.005	<.005	<.005	<.005	<.005
Y	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001
ZN	.004	.006	<.005	<.0001	<.004	<.0002	<.0001	<.009	<.0001	<.0001	.03	<.0004	.004	.05	.1
ZR	<.003	<.003	<.003	<.003	<.003	<.003	<.003	<.005	<.005	<.008	<.003	<.003	<.003	<.003	<.003